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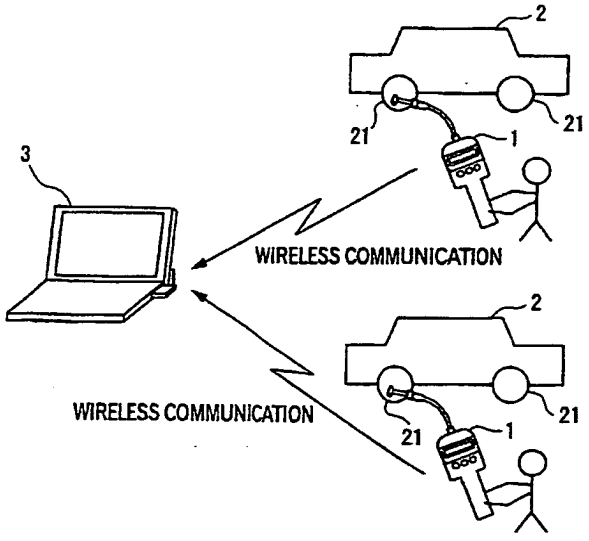
(54) Abstract Title

Tyre pressure gauge and measuring system having wireless data transmission

(57) A pressure gauge 1 has a pressure sensor, a processor, a transmitter and an operating portion. Pressure is measured by the gauge and transmitted to an data processor 3. The processor may be adapted to output a cancel code for cancellation of the previous data transmission. The transmitter may have changeable transmission identification.

The embodiment shows a number of hand held vehicle tyre pressure gauges 1 where pressure values are wirelessly transmitted to a data processor 3 along with gauge identification data. The gauges have a detachable tube to connect to the tyre and an LCD display. The display may display a pressure value using plural pressure units. The processor may include a hold function to hold the current measured value. Various functions such as cancellation of the previously transmitted data value, calibration and ID setting can be carried out at the gauge using input buttons. Calibration involves multi-point compensation. Alternative measuring instruments (e.g. tyre depth) may be used.

FIG.1



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This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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FIG. 1

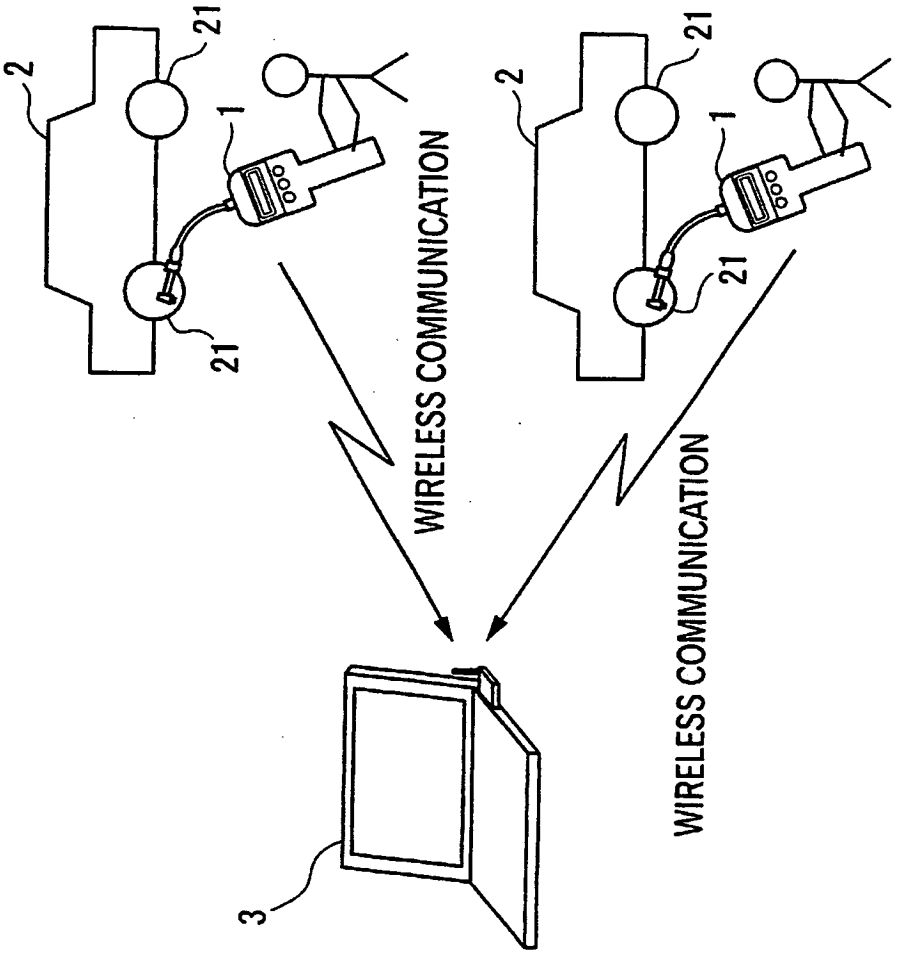
2
21
1
21
WIRELESS COMMUNICATION
2
21
1
21
WIRELESS COMMUNICATION
3

FIG. 2

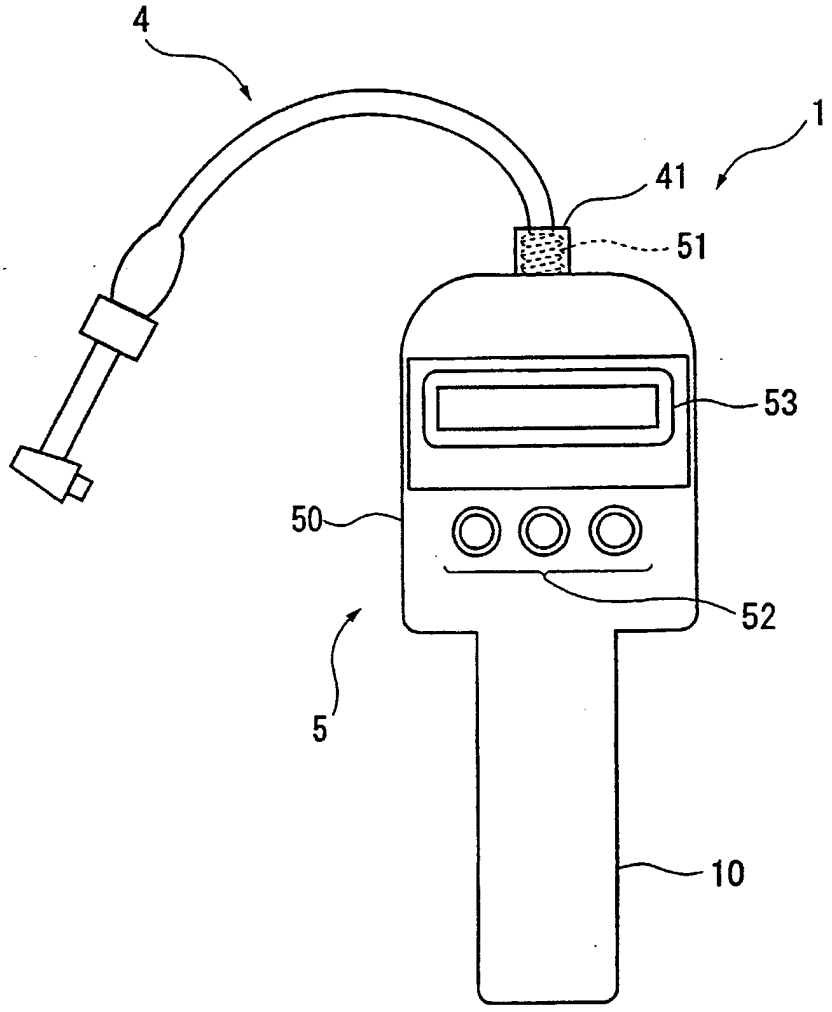

FIG. 3

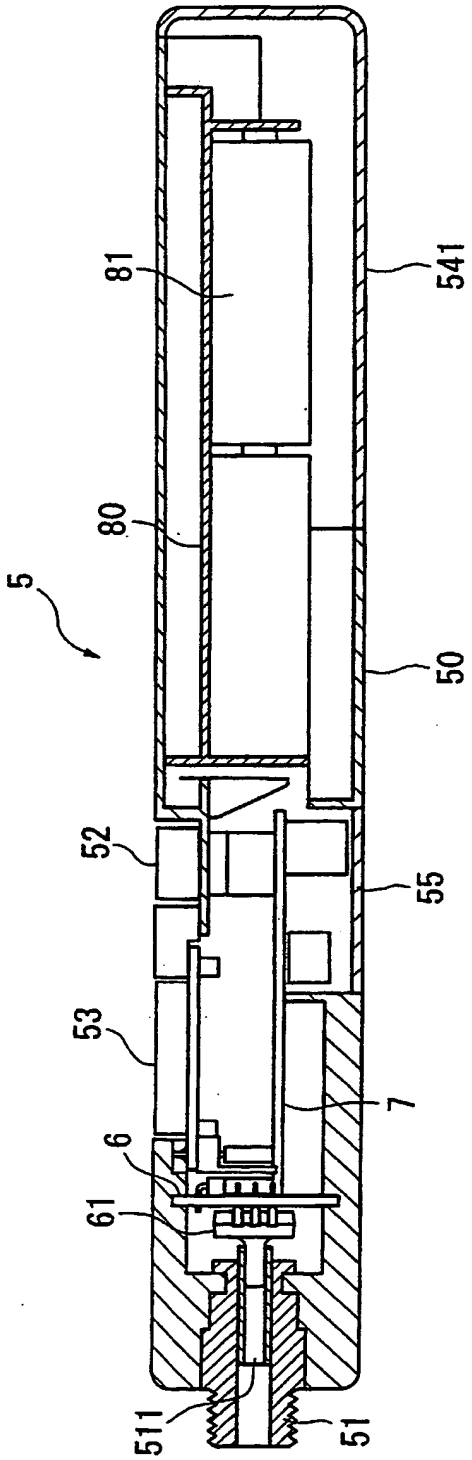

FIG. 4

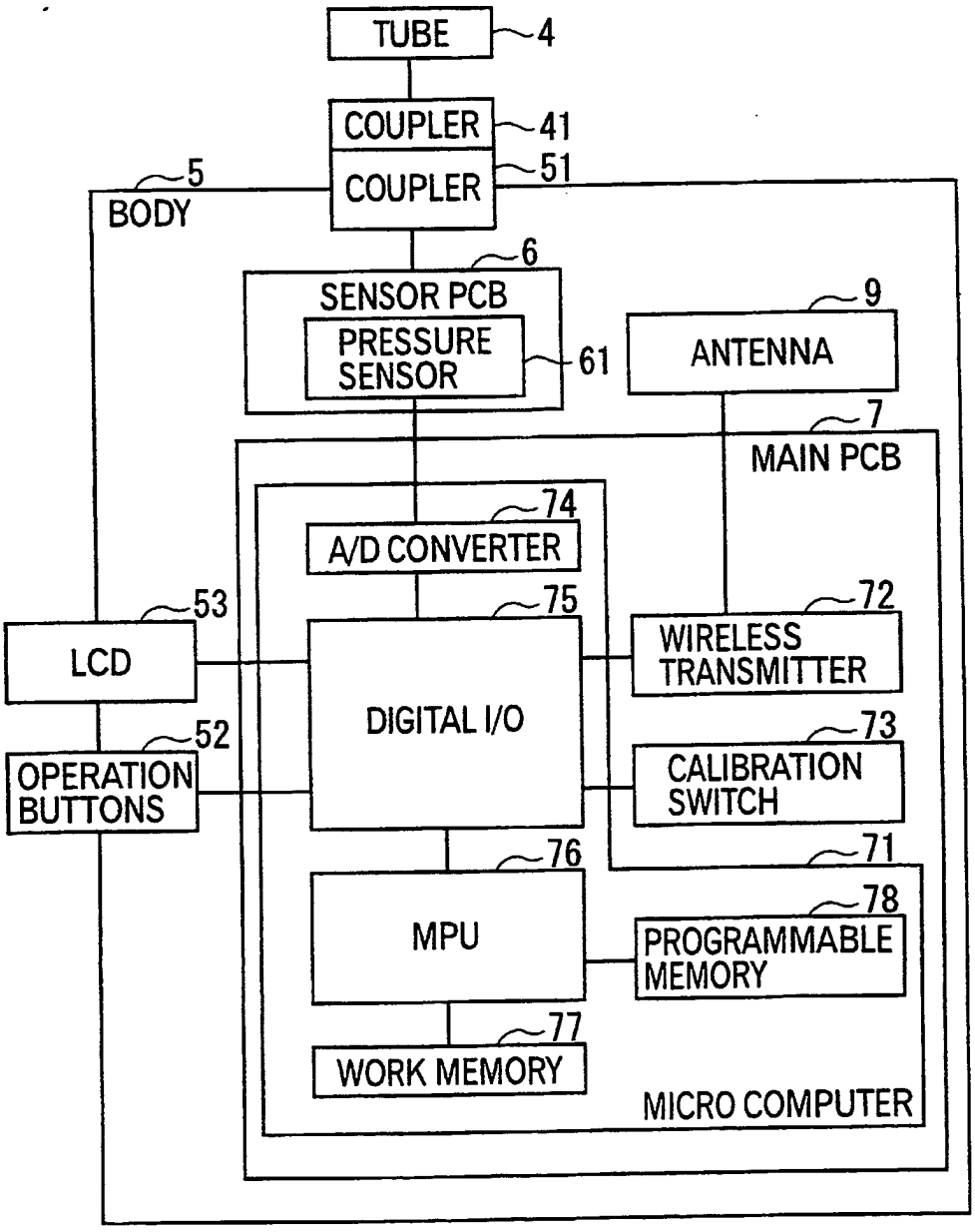
TUBE
4
COUPLER
41
COUPLER
51
5
BODY
6
SENSOR PCB
PRESSURE SENSOR
61
9
ANTENNA
7
MAIN PCB
74
A/D CONVERTER
53
LCD
75
DIGITAL I/O
72
WIRELESS TRANSMITTER
52
OPERATION BUTTONS
73
CALIBRATION SWITCH
76
MPU
71
78
PROGRAMMABLE MEMORY
77
WORK MEMORY
MICRO COMPUTER

FIG. 5

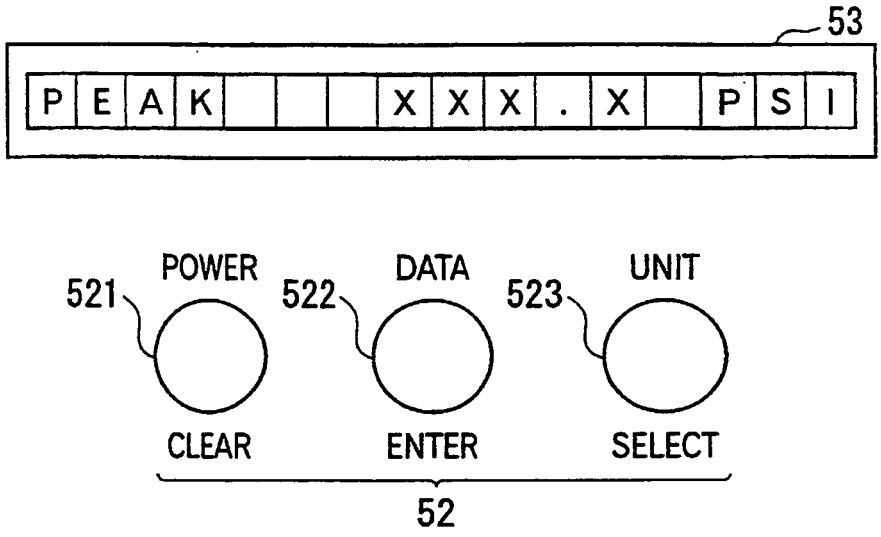
53
P E A K X X X . X P S I
521
POWER
CLEAR
522
DATA
ENTER
523
UNIT
SELECT
52

FIG. 6

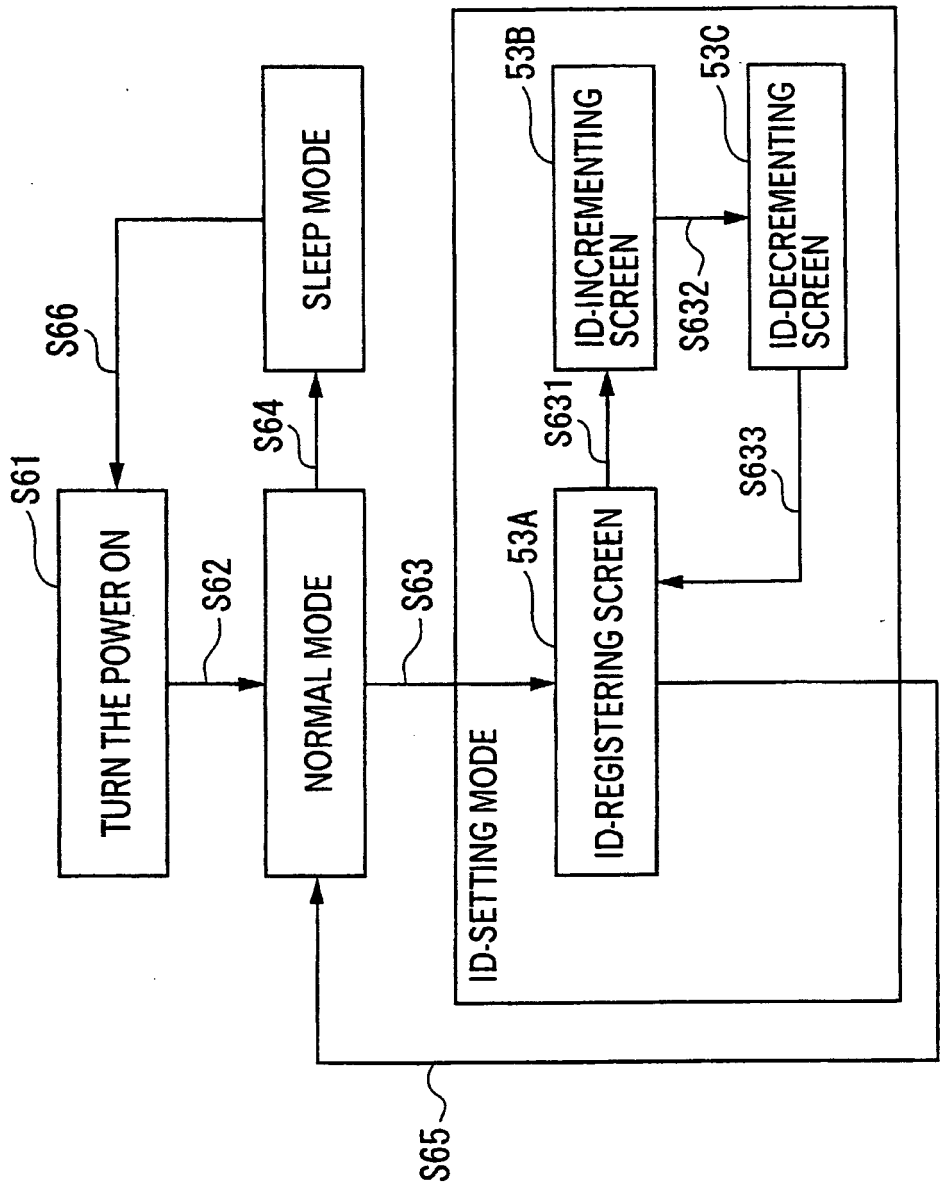
TURN THE POWER ON
S61
S62
NORMAL MODE
S63
S64
SLEEP MODE
S66
ID-SETTING MODE
53A
ID-REGISTERING SCREEN
S631
53B
ID-INCREMENTING SCREEN
S632
53C
ID-DECREMENTING SCREEN
S633
S65

FIG. 7

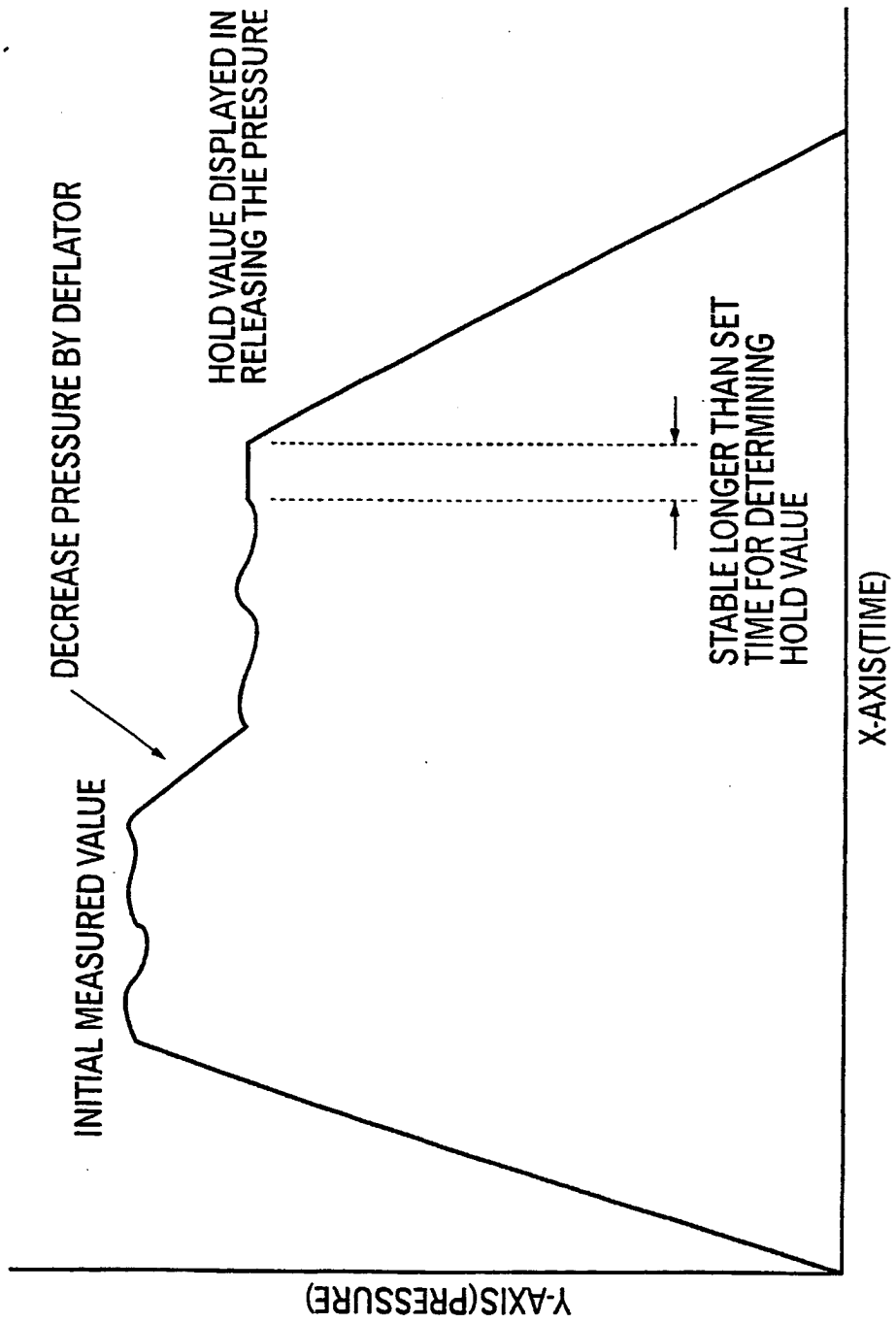
INITIAL MEASURED VALUE
DECREASE PRESSURE BY DEFLATOR
HOLD VALUE DISPLAYED IN RELEASING THE PRESSURE
STABLE LONGER THAN SET TIME FOR DETERMINING HOLD VALUE
X-AXIS(TIME)
Y-AXIS(PRESSURE)

FIG. 8

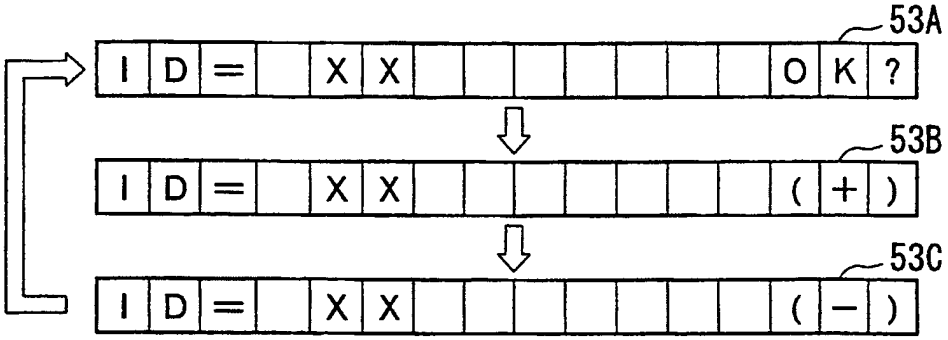

FIG. 9

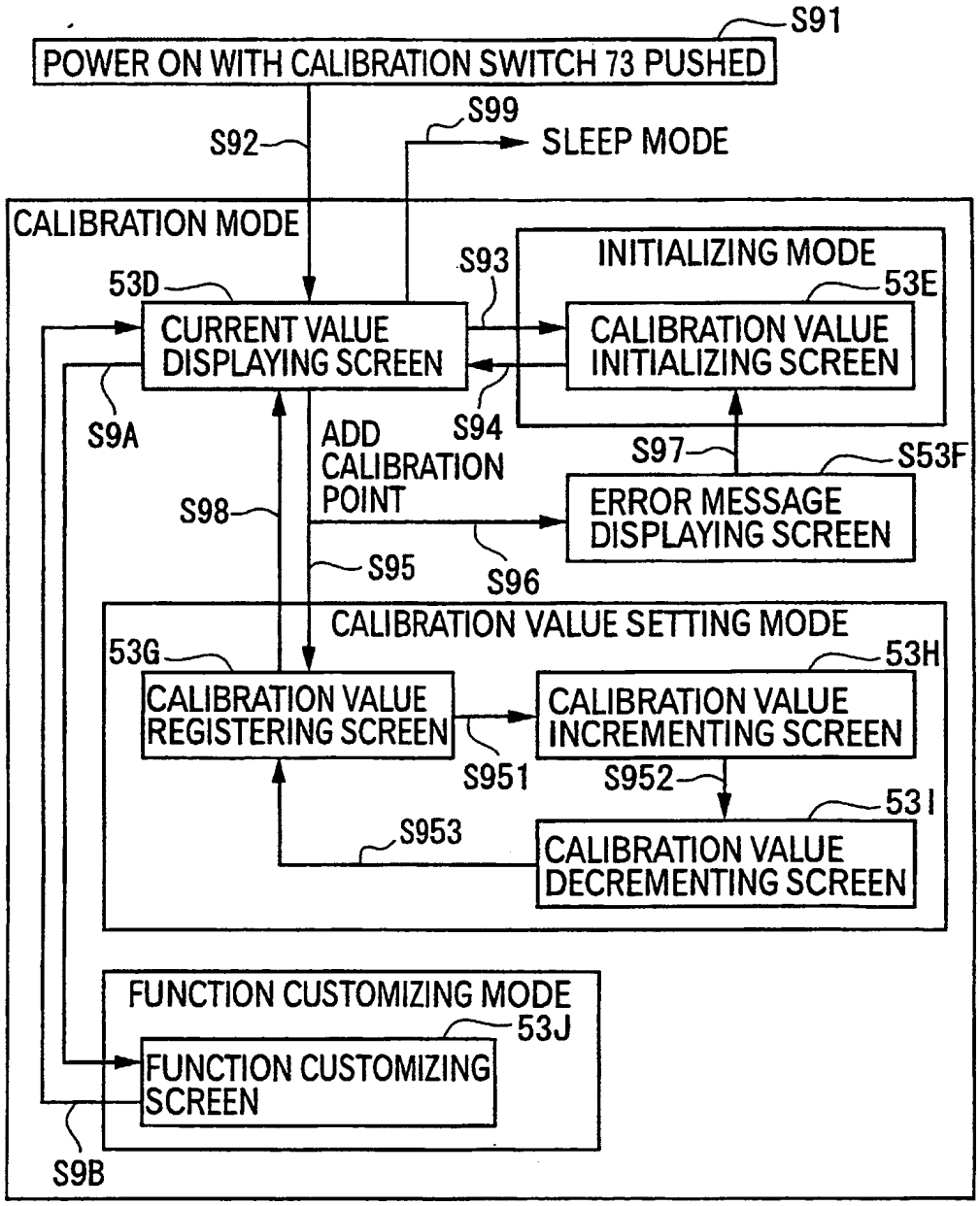
S91
POWER ON WITH CALIBRATION SWITCH 73 PUSHED
S92
S99
SLEEP MODE
CALIBRATION MODE
INITIALIZING MODE
S93
53D
53E
CURRENT VALUE DISPLAYING SCREEN
CALIBRATION VALUE INITIALIZING SCREEN
S9A
S94
ADD CALIBRATION POINT
S97
S53F
S98
ERROR MESSAGE DISPLAYING SCREEN
S95
S96
CALIBRATION VALUE SETTING MODE
53G
53H
CALIBRATION VALUE REGISTERING SCREEN
CALIBRATION VALUE INCREMENTING SCREEN
S951
S952
53I
S953
CALIBRATION VALUE DECREMENTING SCREEN
FUNCTION CUSTOMIZING MODE
53J
FUNCTION CUSTOMIZING SCREEN
S9B

FIG.10

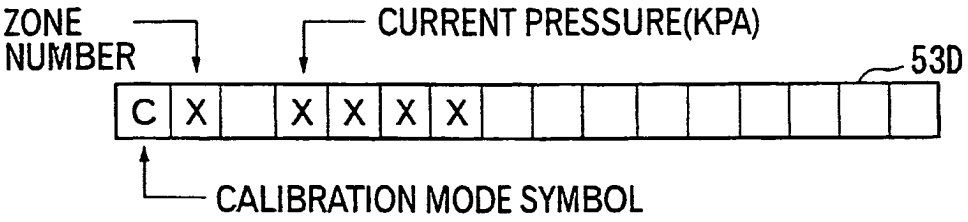

FIG.11

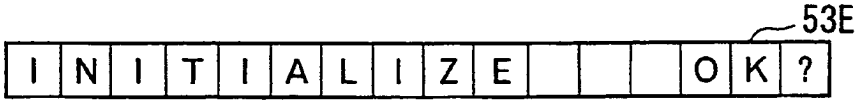

FIG.12

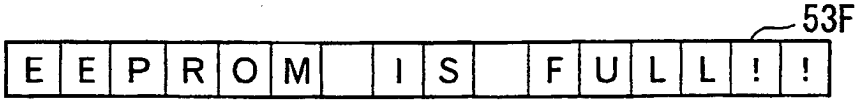

FIG. 13

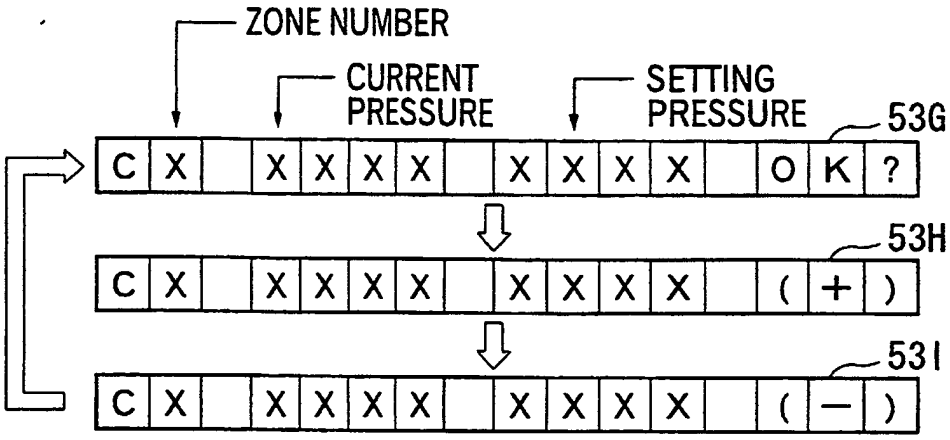
ZONE NUMBER
CURRENT PRESSURE
SETTING PRESSURE
53G
C X X X X X X X X O K ?
53H
C X X X X X X X X (+)
53I
C X X X X X X X X (−)

FIG. 14

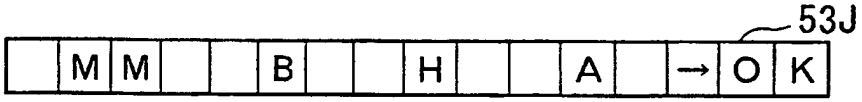
53J
M M B H A → O K

FIG. 15

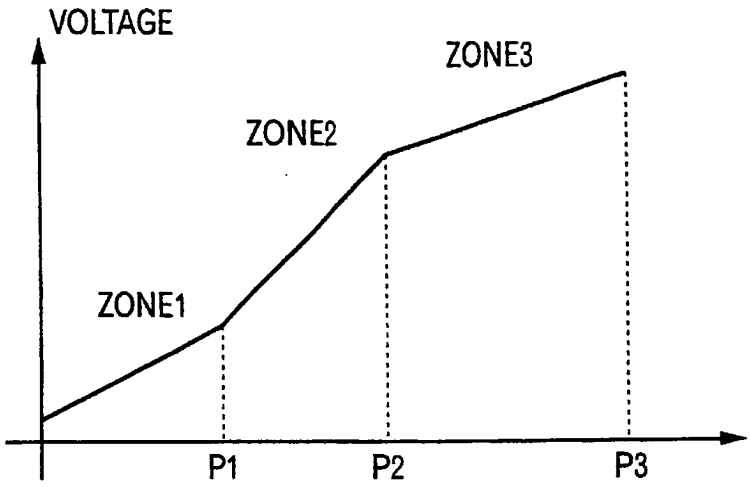

FIG. 16

Pn	Vn	X	X
Pi	Vi	Ai	Bi
P2	V2	A2	B2
P1	V1	A1	B1
P0	V0	A0	B0

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PRESSURE GAUGE AND PRESSURE MEASURING SYSTEM

The present invention relates to a pressure gauge and a pressure measuring system. More specifically, it relates to a hand-held pressure gauge for measuring tire pressure of a vehicle and a pressure measuring system having the pressure gauge.

Conventionally, a pressure gauge for measuring fluid pressure is used in many areas. For example, the pressure gauge is installed in a plant or a device. The pressure gauge is also applied as a hand-held tool.

A tire pressure gauge as the hand-held tool is used for measuring air pressure in a tire of a vehicle.

The tire pressure gauge has, for example, a tube connected with an air inlet of the pressure gauge, and the tip of the tube has a coupler connected with a valve of the tire. In addition to a conventional mechanical detector using a detecting element such as a diaphragm or a Bourdon-tube, an electric detector using a detecting element such as a piezoelectric element can be used as detector of the pressure gauge. A digital display as well as an indicator display can be used as a displaying element.

Such tire pressure gauge can be used for maintaining or adjusting the tire by an owner of the vehicle or a driver. The tire pressure gauge is also frequently used by a vehicle dealer, a maintenance service factory, a garage, a tire shop etc., where tires are handled on business.

Incidentally, when the tire pressure is measured on business, the owner of the vehicle or the driver sometimes requires a report in addition to a normal maintenance. Accordingly, it is necessary to record a measured result of the tire pressure gauge.

Generally, the registering is done by transcribing a measured value displayed on a tire pressure gauge to a record sheet, which is repeated on plural tires installed in a vehicle. Although data management using a computer is introduced for reporting to the owner or the driver, the measured value is ordinarily entered by hand at desk after measuring the

pressure using the tire pressure gauge.

In other words, since an operation such as transcribing the measured value to the record sheet is necessary for the data management and the transcription and the measurement are repeated, troublesome work is required and mis-transcription is possible.

An object of the present invention is to provide a pressure gauge and a pressure measuring system capable of eliminating the need of transcription of the measured value.

A pressure gauge of the present invention has a pressure sensor for receiving pressure applied from the outside and outputting a signal corresponding to the pressure, a processor for processing the signal from the pressure sensor and calculating a measured value, a transmitter for transmitting the measured value calculated by the processor to the outside, and an operating portion for operating the processor and the transmitter.

According to the above arrangement, the measured value can be obtained by the pressure gauge and the processor, and the measured value is transmitted from the transmitter to the outside and processed by a data processor etc. to compile or print the measured value. Accordingly, the need of the transcription to the record sheet etc. by conventional manual transcription can be eliminated.

Any existing semi-conductor pressure sensor element etc. can be used as the pressure sensor, and a mechanical pressure gauge etc. having electrical signal outputting means can be used.

Any existing built-in microcomputer etc. can be used as the processor. The microcomputer etc. as the processor may control the whole pressure gauge including the pressure sensor, the transmitter and the operating portion.

Any existing device for data communication can be used as the transmitter, and any communication medium (cable or wireless) and data form can be used thereto.

Existing various switches can be used as the operating portion. Considering use outside or under dusty environment, the switches may preferably be so-called membrane switches having high dust/water-proof ability.

In the present invention, the processor may preferably be adapted to output a cancel code for cancelling preceding transmission data from the transmitter in response to cancel operation of the operating portion.

According to the above arrangement, even when a mis-measured value is transmitted during measurement operation, the mis-measured value can be easily cancelled, so that problems of directly using the mis-measured value can be prevented. For example, a correct measured value may not be obtained if the pressure gauge is insufficiently connected to a workpiece such as a tire or if mis-operation such as transmission operation is implemented before the measured value is stabilized. Although it is possible to go to the data processor and cancel the measured value when the mis-measured value is transmitted, operation efficiency is deteriorated. However, if preceding transmission data can be cancelled by transmitting the cancel code, operation and subsequent data processing can be facilitated.

In the present invention, the transmitter may preferably be in wireless communication with an external receiver.

According to the above arrangement, since wireless communication is employed, a cable for transmitting data is not necessary, so that operation efficiency around the workpiece such as a tire can be improved.

In the above arrangement, the transmitter may preferably have a changeable transmission ID (transmission identification).

According to the above arrangement, even when plural pressure gauges are used in the same wireless communication area, each pressure gauge can be identified by the transmission ID thereof. Accordingly, the pressure gauge can be widely applied to a field where measuring operations using plural pressure gauges are simultaneously carried out in the same measuring pit.

The pressure gauge of the present invention may preferably have a display for displaying the measured value and status of each component.

According to the above arrangement, since the measured value is not only transmitted but also can be visually checked at the measuring site, measuring circumstance can be easily monitored and an irregular situation can be easily recognized. Further, the pressure gauge can be used for supplying air pressure into tire as in a conventional pressure gauge.

In the present invention, the measured value may preferably be converted to be displayed in a predetermined pressure unit in real time.

According to the above arrangement, the pressure gauge of the present invention

can be used in various region or environment where specific pressure unit such as PSI, Bar, KPa is required.

Further, plural pressure units may be simultaneously displayed.

According to the above arrangement, even when the plural units relating to operations are required to be displayed, a switching operation to switch the plural units in turn can be omitted. Accordingly, operation efficiency can be improved when different workpieces are measured to be displayed in different units.

Any existing display element such as an LCD (liquid crystal display) panel can be used as the display. A segment display type for displaying predetermined characters, a dot matrix display for displaying optional characters and figures etc. can be selected.

The pressure gauge of the present invention may preferably have a detachable module for accessing the external pressure.

According to the above arrangement, measuring operation can be facilitated by selecting a module in accordance with operation circumstances and situations. For example, a solid pipe module is convenient in case of accessing valves in same attitude continuously.

On the other hand, when directions of valves are not determined as in a tire, operation efficiency can be improved by using a flexible tube module to keep a constant attitude of the pressure gauge irrespective of the directions of the valves.

Although wearing of pressure access point cannot be avoided in use, the detachable module can be easily replaced.

In the present invention, the pressure sensor may preferably be fixed to a PCB (printed circuit board) and capable of being replaced together with the PCB.

In case that the pressure sensor is deteriorated or damaged, the pressure sensor needs to be replaced. However, troublesome operation in replacement such as connecting a lead wire to the pressure gauge is not necessary when the pressure sensor is replaced together with the PCB, so that the pressure gauge can be replaced by simple operation using an existing connector etc.

In the present invention, the processor may preferably include a software calibration routine by multi-point compensation.

In the arrangement, accuracy calibration of the pressure sensor can be securely carried out, and calibration operation can be simplified by using the software calculation

routine. Further, since hardware calibration means is not necessary, calibration operation can be easily carried out at any time and site. Accordingly, calibration in accordance with characteristics of each pressure sensor can be securely carried out each time the pressure sensor is replaced, so that accurate measurement can be constantly carried out.

In the above arrangement, the processor may preferably include a built-in calibration routine for the above calculation.

According to the above arrangement, an external calibration device is not necessary and calibration can be carried out in the pressure gauge. Accordingly, the calibration can be easily carried out each time the pressure sensor is replaced, so that accurate measurement can be constantly carried out.

In the present invention, the processor may preferably have a hold function to hold the current measured value.

According to the above arrangement, continuously fluctuating measured value can be held. Accordingly, the measured value can be easily read by visual reading. Further, when the displayed measured value is confirmed prior to the transmission, abnormal data in measurement operation can be easily found.

In the above arrangement, the hold function may be a stable-value auto-hold function to automatically hold the measured value stable for a predetermined time in one measurement cycle, or a peak-value auto-hold function to automatically hold the maximum measured value in one measurement cycle. The phrase "stable for a predetermined time" means, for example, that a fluctuation range of the measured value for the predetermined time is within a predetermined range.

According to the above arrangement, when data transmission operation is performed to the operating portion while pressure is applied to the pressure gauge, the current value can be transmitted by the transmitter, and when the transmission operation is performed while pressure is not applied to the pressure gauge, the previous hold value can be transmitted by the transmitter. Accordingly, more effective operation can be performed.

Further, the hold function may be a manual-hold function to optionally hold the measured value by an operator performing manual operation.

According to the above arrangement, measurement target of which pressure is easily fluctuated can be optionally measured by using the two auto-hold functions to carry

out transmission operation while pressure is applied to the target. Further, stable measurement operation can be done by executing the auto-hold functions to carry out transmission operation after releasing the pressure. Furthermore, the manual-hold function enables to carry out measurement operation that the two auto-hold functions cannot deal with. Accordingly, various measurement operations can be flexibly carried out.

In the above arrangement, the processor may preferably reset the hold value when hold value reset operation is carried out on the operating portion and/or when the next pressure is applied to the pressure gauge.

According to the above arrangement, the hold value can be freely reset by the reset operation, and the operation efficiency can be improved by auto-hold-reset in conducting continuous measurement.

A pressure measuring system of the present invention has a pressure gauge having a pressure sensor for receiving pressure applied from the outside and outputting a signal corresponding to the pressure, a processor for processing the signal from the pressure sensor and calculating a measured value, a transmitter for transmitting the measured value calculated by the processor to the outside, and an operating portion for operating the processor and the transmitter. The pressure measuring system further has a data processor having a receiver for receiving the measured value from the transmitter and a processing portion for conducting a predetermined data processing to the received value.

According to the above arrangement, pressure of a workpiece is measured by the pressure gauge to transmit the measured value from the pressure gauge to the data processor, and registering, processing, printing etc. can be carried out in the data processor. Specifically, the measured value can be obtained by the pressure sensor and the processor, and the measured value is transmitted from the transmitter to the receiver. Further, necessary data processing is carried out in the processing portion. Accordingly, the need of the transcription to the record sheet etc. by conventional manual transcription can be eliminated.

The pressure sensor, the processor, the transmitter and the operating portion are the same as those explained about the aforesaid pressure gauge. Any receiver capable of being in communication with the transmitter may be used. Any existing computer system etc. can be used as the processing portion to carry out necessary processing such as

registering, processing and printing.

In the present invention, the processor may preferably output a predetermined cancel code in response to cancel operation of the operating portion, and the receiver may preferably cancel the preceding transmission data when the receiver receives the cancel code from the transmitter.

According to the above arrangement, even when a mis-measured value is obtained during measurement operation, the mis-measured value can be easily cancelled, so that problems of directly using the mis-measured value can be prevented. For example, a correct measured value may not be obtained if the pressure gauge is insufficiently connected to a workpiece such as a tire or if mis-operation such as transmission operation is implemented before the measured value is stabilized.

Although it is possible to go to the data processor and cancel the measured value when the mis-measured value is transmitted, the operation efficiency is deteriorated. However, if the preceding transmission data can be cancelled by transmitting the cancel code, operation and subsequent data processing can be facilitated.

In the present invention, the transmitter may preferably be in wireless communication with the receiver.

According to the above arrangement, since wireless communication is employed, a cable for transmitting data is not necessary, so that the operation efficiency around the workpiece such as a tire can be improved.

In the above arrangement, the receiver may preferably be adapted to connect a communication channel with plural transmitters and identify each transmitter by a transmission ID.

According to the above arrangement, even when plural pressure gauges are used in the same wireless communication area, each pressure gauge can be identified by the transmission ID thereof. Accordingly, the pressure gauge can be widely applied to a field where measuring operations using plural pressure gauges are simultaneously carried out in the same measuring pit.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram of a pressure measuring system of an embodiment of the present invention;

Fig. 2 is a front appearance of a pressure gauge of the aforesaid embodiment;

Fig. 3 is a vertical sectional view taken along a centreline in width direction of the body of the pressure gauge of the aforesaid embodiment;

Fig. 4 is a block diagram of the pressure gauge of the aforesaid embodiment;

Fig. 5 is an illustration showing arrangement of an operating part and a display of the pressure gauge of the aforesaid embodiment;

Fig. 6 is a flowchart of normal operation routine of the aforesaid embodiment;

Fig. 7 is a graph showing an auto-hold function of the aforesaid embodiment;

Fig. 8 shows a screen of ID setting mode of the aforesaid embodiment;

Fig. 9 is a flowchart of calibration routine of the aforesaid embodiment;

Fig. 10 shows a screen of calibration mode of the aforesaid embodiment;

Fig. 11 shows a screen of calibration value initializing mode of the aforesaid embodiment;

Fig. 12 shows an error message displaying screen of the aforesaid embodiment;

Fig. 13 shows a screen of calibration value setting mode of the aforesaid embodiment;

Fig. 14 shows a screen of function customizing mode of the aforesaid embodiment;

Fig. 15 is a graph showing a method of multi-point compensation of the aforesaid embodiment; and

Fig. 16 is a schematic view showing a multi-point compensation parameter table of the aforesaid embodiment.

An embodiment of the present invention will be explained below with reference to the drawings.

[Arrangement of the embodiment]

Fig. 1 shows a schematic arrangement of a pressure measuring system S of the present invention.

The pressure measuring system S has plural pressure gauges 1 respectively connected to tires 21 of automobiles 2 and a data processor 3 for communicating with each pressure gauge 1.

Each pressure gauge 1 is connected to each tire 21 of the automobiles 2 to measure pressure of each tire 21 and transmits measured pressure values of the tires 21 with individual transmission ID (transmission identification) to the data processor 3 by wireless communication.

The data processor 3 determines which pressure gauge 1 has transmitted received data based on received transmission ID and uses the data received from the pressure gauge 1 as a part of database of vehicles or customers.

Fig. 2 shows a front appearance of the pressure gauge 1 of the present embodiment.

The pressure gauge 1 has a tube 4 and a body 5. An end of the tube 4 is connected to the tire 21, while the other end is detachably connected to the body 5 with a screw coupler 41 of the tube 4 and a screw coupler 51 of the body 5. Accordingly, the pressure of the tire 21 is applied into the body 5 though the tube 4. The tube 4 can be replaced with various modules such as soft tube or solid pipe which has a screw coupler of the same shape as the coupler 41.

The body 5 is a resin moulding made of ABS (acrylonitrile butadiene styrene) and consists of a body case 50 composed of upper and lower halves. Operation button 52 and sixteen-character monochrome LCD (liquid crystal display) 53 are provided on the front centre of the body 5. The operation button 52 is used for operations such as measuring pressure, setting plural functions and transmitting measured data. The LCD 53 displays the measured value, setting messages of the functions etc.

A cylindrical grip 10 is provided on the lower side of the body 5, which is slimmer than the upper side of the body 5 for easy gripping.

Fig. 3 shows an internal arrangement of the body of the pressure gauge of the present embodiment.

A sensor PCB 6, a main PCB 7 and a cell case 80 are provided in the body 5, the cell case 80 accommodating four AA batteries 81 (commercially available, for example, UM3 type). The sensor PCB 6 is perpendicular to the coupler 51 and has a pressure sensor 61 fixed thereon, which is connected with the coupler 51.

The pressure sensor 61 is a gauge pressure sensor and can be replaced with another pressure sensor 61 together with the sensor PCB 6 when the pressure sensor 61 is damaged. The pressure sensor 61 receives the pressure of the tire 21 applied though the

tube 4 and outputs analogue electric signal corresponding to the pressure.

The coupler 51 is connected to the pressure sensor 61 with a tube 511 and held by the two halves of the case body 50 to be fixed thereto.

The main PCB 7 is perpendicularly connected to the sensor PCB 6 with board-to-board connector.

Connectors of the operation button 52 and the LCD 53 are perpendicularly connected to connectors of the main PCB 7, so that the main PCB 7 is separately connected to the operation button 52 and the LCD 53.

A detachable back cover 55 is provided on the back of the body case 50 for accessing the main PCB 7.

The cell case 80 is provided in the grip 10 and is usually not seen from the outside. By removing a battery cover 541 detachably provided in the grip 10, four AA batteries 81 can be removed or housed into the cell case 80.

Fig. 4 shows a system arrangement of the pressure gauge of the present embodiment.

As explained above, the sensor PCB 6 is connected with the main PCB 7.

The main PCB 7 has a microcomputer 71, a wireless transmitter 72 and a calibration switch 73.

The microcomputer 71 includes an A/D converter (analogue/digital converter) 74, a digital I/O (digital input/output interface) 75, a MPU (microprocessor unit) 76, a work memory 77 and a programmable memory 78. The A/D converter 74 converts analogue signal from the pressure sensor 61 into digital signal and transmits the digital signal to the digital I/O 75. The digital I/O 75 is separately connected to the A/D converter 74, the operation button 52, the LCD 53, the wireless transmitter 72, the MPU 76 and the calibration switch 73. The MPU 76 is connected to the work memory 77 and the programmable memory 78 in addition to the digital I/O 75.

The microcomputer 71 has the following functions of:

(1) Processing the signal from the pressure sensor 61 converted by the A/D converter 74 and calculating measured value;

(2) Holding the measured value in accordance with below-described predetermined rule (Hold function);

(3) Resetting the hold value by the hold function in accordance with below-described

predetermined rule;

(4) Displaying the measured value or the hold value on the LCD 53;

(5) Converting the measured value or hold value in real time according to the selected pressure unit.

(6) Setting and changing the transmission ID, which is from 0 to 99, by operating the operation button 52 and registering the transmission ID in the programmable memory 78;

(7) Transmitting the measured value or the hold value from the wireless transmitter 72 by data-transmitting operation of the operation button 52;

(8) Outputting a cancel code for cancelling the preceding transmission data from the wireless transmitter 72 by cancelling operation of the operation button 52;

(9) Conducting software calibration with multi-point compensation; and

(10) Calibrating the calculation processing.

The above functions can be realized by running a program recorded in the programmable memory 78 by the microcomputer 71.

The functions (1) to (8) are hereinafter called "normal operation routine". The function (9) is called "multi-point compensation routine". The function (10) is called "calibration routine".

The programmable memory 78 is specifically an EEPROM (electrically erasable programmable read-only memory), which records data such as the transmission ID and multi-point compensation data. The program can be rewritten through a socket fixed onto the main PCB 7 on the side of the back surface of the body 5.

The wireless transmitter 72 is connected to the digital I/O 75 and an antenna 9 provided on the body 5. The wireless transmitter 72 can communicate with the data processor 3 by wireless communication and intermediate communication between the microcomputer 71 and the data processor 3.

The calibration switch 73 is used for entering into the calibration routine, which is provided on the main PCB 7 on the side of the back surface of the body 5. The calibration switch 73 is usually not seen from the outside and is exposed when the back cover 55 is detached.

Fig. 5 shows an exterior of an operating part and a display of the pressure gauge of the present embodiment.

The operation button 52 as the operating portion has horizontally-aligned three buttons, which are a POWER/CLEAR button 521 (P/C button 521) on the left side, a DATA/ENTER button 522 (D/E button 522) in the middle and an UNIT/SELECT button 523 (U/S button 523) on the right side. These buttons 521 - 523 are used for operating the pressure gauge 1, all of the buttons being membrane dust-proof type.

The sixteen-character monochrome LCD 53 as the display is provided on the upper side of the operation button 52 and displays the measured value and screens for setting each function etc.

The data processor 3 has a wireless receiver, which may be a desktop type or may be a PCMCIA card type, and a notebook computer as a data processing portion (both of which are not shown). The wireless receiver can be attached to and detached from the notebook computer and can communicate with the wireless transmitter 72.

Customers' names, vehicle numbers and ID codes of the pressure gauges 1 are stored in the notebook computer in advance, in which the measured value received by the wireless receiver is classified based on the ID codes and recorded in database specified for each vehicle (registered) number and customers' name. When receiving the cancel code, the notebook computer deletes the preceding data corresponding to the ID code.

The recorded data can be searched on customer database and vehicle database.

Fig. 6 shows a flowchart of the normal operation routine of the present embodiment.

When an operator turns the power of the pressure gauge 1 on (Step S61), operation mode of the pressure gauge 1 is changed to normal mode for measuring pressure and transmitting the measured data (Step S62).

When the measured value is stable, for instance, over 500ms after receiving the pressure of the tire 21 in the normal mode, the stable value is automatically held (Auto-hold function) (see Fig. 7).

When the measured value becomes zero after holding the value and the pressure is re-applied, the value-holding is automatically reset (Auto-hold-reset function).

When below-described operations are done in the normal mode,, the operation mode of the pressure gauge 1 is changed to ID setting mode for setting the transmission ID or sleep mode in which the power of the pressure gauge 1 is turned off (Steps S63, S64).

As shown in Fig. 8, an ID-registering screen 53A for registering displayed ID

number is displayed in the ID setting mode, and then, an ID-incrementing screen 53B for incrementing the ID number and an ID-decrementing screen 53C for decrementing the ID number are displayed in this order (Steps S63, S631 and S632). The ID-registering screen 53A is displayed after the ID-decrementing screen 53C (Step S633). When the ID number is recorded on the ID-registering screen 53A, the operation mode of the pressure gauge 1 is changed to the normal mode (Step S65).

When the power of the pressure gauge 1 is turned on again in the sleep mode, the mode of the pressure gauge 1 is returned to the normal mode (Step S66).

Incidentally, the power of the pressure gauge 1 can be turned off by manual operation of the operator (Manual-sleep function). In addition, when no operation is carried out for a predetermined time (five minutes, for example) in the normal mode, the mode of the pressure gauge 1 is automatically changed to the sleep mode (Auto-sleep function).

The manual-sleep function is arranged to turn the power off by pushing the P/C button 521 for a predetermined time (two seconds, for instance) in order not to improperly turn the power off by wrong operation.

The P/C button 521, the D/E button 522 and the U/S button 523 are arranged to work as follows in each mode of normal operation.

When the D/E button 522 is pushed once while the measured value (the hold value) is displayed in the normal mode, an arrow "←" is displayed on the LCD 53. Then, when the D/E button 522 is released, the measured value (the hold value) is transmitted.

When the D/E button 522 is pushed for 2-4 seconds and released thereafter in the normal mode, "CANCEL" is displayed instead of the measured value. Then, when the D/E button 522 is released, cancel code to delete the previous transmitted value (with ID number) is transmitted.

When the D/E button 522 is pushed over 4 seconds in the normal mode, the mode of the pressure gauge 1 is changed to the ID setting mode.

When the P/C button 521 is pushed once in the normal mode, the measured value (the hold value) is cleared and a new measured value is displayed.

When the P/C button 521 is pushed over 2 seconds in the normal mode, the power of the pressure gauge 1 is turned off (changing to the sleep mode).

Each time the U/S button 523 is pushed in the normal mode, the unit of the

displayed measured value is switched between Bar and PSI or between KPa and PSI.

The above pairs of the units (Bar/PSI and KPa/PSI) can be selected by customizing functions described below.

Each time the U/S button 523 is pushed in the ID setting mode, the screen of the LCD 53 is switched in the order of the ID-incrementing screen 53B, the ID-decrementing screen 53C and the ID-registering screen 53A.

When the P/C button 521 is pushed once on any of the ID-incrementing screen 53B, the ID-decrementing screen 53C or the ID-registering screen 53A, the mode of the pressure gauge 1 is returned to the normal mode. However, this operation doesn't change the ID number.

The ID number is incremented by one each time the D/E button 522 is pushed on the ID-incrementing screen 53B, and the ID number is continuously incremented when the D/E button 522 is continuously pushed. The ID number is decremented by one each time the D/E button 522 is pushed on the ID-decrementing screen 53C, and the ID number is continuously decremented when the D/E button 522 is continuously pushed.

When the D/E button 522 is pushed once on the ID-registering screen 53A, an ID number displayed at the moment is set as a new ID number and the operation mode of the pressure gauge 1 is returned to the normal mode.

Incidentally, the unit KPa is used for data processing inside the pressure gauge 1, which the unit is converted by software in displaying the data on the outside or in transmitting the data to the outside. The displayed unit can be changed at any time, which may be changed immediately before display or data transmission.

Fig. 9 shows a flowchart of the calibration routine of the present embodiment.

When the operator detaches the back cover 55 and pushes the calibration switch 73 when turning the power of the pressure gauge 1 on (Step S91), the operation mode of the pressure gauge 1 is changed to calibration mode to initialize and add the calibration value, and to customize functions (Step S92).

As shown in Fig. 9, calibration value initialization started by pressing the P/C button 521 (Steps S93, S94), calibration point addition started by pressing the D/E button 522 (Steps S95, S951 to S953 and S98), and function customizing started by pressing the U/S button 523 (Steps S9A, S9B) are available in calibration mode.

When the operation mode of the pressure gauge 1 is changed to the calibration

mode, the LCD 53 displays a current value displaying screen 53D (Fig. 10) for displaying a calibration mode symbol "C", a zone number and the current pressure value (unit KPa) from left to right (Step S92).

After confirming the displayed data on the current value displaying screen 53D, the operation mode is changed to initializing mode to initialize the calibration value or calibration value setting mode to add the calibration value or sleep mode in which the power of the pressure gauge 1 is turned off or function customizing mode to customize various functions (Steps S93, S95, S99 and S9A).

In the initializing mode, a calibration value initializing screen 53E (Fig. 11) to initialize the calibration value is displayed, and when the initialization of the calibration value is completed, the current value displaying screen 53D is displayed (S94).

When the calibration value setting mode is selected and the programmable memory 78 has no registration space, an error message displaying screen 53F (Fig. 12) to display the status is displayed and the operation mode is shifted to the initializing mode (Steps S96, S97). Then, the calibration value is initialized in the initializing mode, and the operation mode is shifted to the calibration value setting mode via the current value displaying screen 53D (Steps S94, S95).

When the operation mode is shifted to the calibration value setting mode, as shown in Fig. 13, a calibration value registering screen 53G to register the displayed calibration value is displayed, and then, a calibration value incrementing screen 53H to increment the calibration value and a calibration value decrementing screen 53I to decrement the calibration value are displayed in this order (Steps S95, S951, S952). The calibration value registering screen 53G is displayed after the calibration value decrementing screen 53I (Step S953).

The calibration value registering screen 53G displays a calibration symbol "C", a zone number, the current pressure value, set pressure value (unit KPa) and characters "OK" from left to right in this order.

The calibration value incrementing screen 53H displays the calibration symbol "C", the zone number, the current pressure value, the set pressure value (unit KPa) and a mark "(+)" from left to right in this order.

The calibration value decrementing screen 53I displays the calibration symbol "C", the zone number, the current pressure value, the set pressure value (unit KPa) and a

mark "(-)" from left to right in this order.

When a new calibration value is set in the calibration value registering screen 53G, the current value displaying screen 53D is displayed (Step S98).

When the operation mode is shifted to the function customizing mode, a function customizing screen 53J (Fig. 14) to customize functions is displayed to select default unit (PSI or Bar/KPa), to select an unit displayed as unit of International Organization for Standardization (ISO) (Bar or KPa), to select auto-hold functions, and to select sleep functions. After the function customizing is completed, the current value displaying screen 53D is displayed (Step S9B).

A stable-value auto-hold function to automatically hold a measured value stable for a predetermined time in one measurement cycle or a peak-value auto-hold function to automatically hold the maximum measured value in one measurement cycle can be selected as the auto-hold function.

As to the sleep functions, a choice in which an auto-sleep function to automatically turn the power off when no operation is carried out for a predetermined time and a manual-sleep function to manually turn the power off by the operator performing manual operation are available, or a choice in which only the manual-sleep function is available can be selected. The manual-sleep function may preferably be arranged to turn the power off by pushing the P/C button 521 for a predetermined time (two seconds, for instance) in order not to improperly turn the power off by wrong operation. Further, the pressure gauge 1 may be arranged to turn the power on by pushing the button for a predetermined time in order to avoid turning the power on by mistake during transportation.

The P/C button 521, the D/E button 522 and the U/S button 523 are arranged to work as follows in each mode for calibration.

When the P/C button 521 is pushed once on the current value displaying screen 53D, the operation mode is changed to the calibration value initializing screen 53E.

When the D/E button 522 is pushed once on the calibration value initializing screen 53E, the calibration value recorded in the programmable memory 78 is cleared and the current value displaying screen 53D is displayed.

When the P/C button 521 is pushed for over 2 seconds on the current value displaying screen 53D, the power of the gauge turns off (sleep mode).

When the D/E button 522 is pushed once on the current value displaying screen 53D, the calibration value registering screen 53G is displayed.

Capacity of the programmable memory 78 is checked in this operation by pushing the D/E button 522 on the screen 53D and if the programmable memory 78 has no capacity to record, an error message displaying screen 53F showing the status is displayed.

When the P/C button 521 is pushed once while the error message displaying screen 53F is displayed, the displayed screen is changed to the calibration value initializing screen 53E.

Each time the U/S button 523 is pushed on the calibration value registering screen 53G, the calibration value incrementing screen 53H, the calibration value decrementing screen 53I and the calibration value registering screen 53G are displayed on the LCD 53 in this order.

When the P/C button 521 is pushed once on any of the calibration value incrementing screen 53H, the calibration value decrementing screen 53I and the calibration value registering screen 53G, the current value displaying screen 53D is displayed without changing the calibration value.

The calibration value is incremented by one when the D/E button 522 is pushed once on the calibration value incrementing screen 53H, and the calibration value is continuously incremented when the D/E button 522 is continuously pushed.

The calibration value is decremented by one when the D/E button 522 is pushed once on the calibration value decrementing screen 53I, and the calibration value is continuously decremented when the D/E button 522 is continuously pushed.

A calibration value displayed at the moment is saved to be added as a new calibration value when the D/E button 522 is pushed once on the calibration value registering screen 53G, and the current value displaying screen 53D is displayed.

The U/S button 523 is pushed once on the current value displaying screen 53D, the function customizing screen 53J is displayed.

The P/C button 521 is pushed on the function customizing screen 53J, the current value displaying screen 53D is displayed without function customizing.

Each time the U/S button 523 is pushed on the function customizing screen 53J, functions to be customized are switched. Specifically, position of a cursor displayed on the screen 53J is shifted among respective select menus of the default units, the ISO units

to be displayed, the hold functions and the sleep functions, and a configuration registering menu to register configuration.

When the D/E button 522 is pushed while the cursor is displayed on each select menu on the screen 53J, choices in each select menu are switched.

When the D/E button 522 is pushed while the cursor is displayed on the configuration registering menu on the screen 53J, the choices of the select menus displayed at that time are registered, and the current value displaying screen 53D is displayed.

The multi-point compensation routine of the present embodiment is implemented as follows.

(1) Default maximum/minimum pressure values of the measuring range and default voltage values corresponding to the default pressure values are recorded in the programmable memory 78. These default values include the minimum value of the measuring range of the pressure sensor 61 (ex. 0 KPa), the minimum voltage value of the pressure sensor 61 corresponding to the minimum value (ex. + 0.2V), the maximum value of the measuring range (ex. 1067 KPa) and the maximum voltage value (ex. + 5V) corresponding to the maximum value.

(2) When the power of the pressure sensor 61 is turned on with the default values being recorded without applying the pressure, a voltage value output by the pressure sensor 61 at the moment is correlated with zero of the pressure value.

(3) A pressure value corresponding to a voltage value between the minimum voltage value and the maximum voltage value is assigned in the following expression of;

$$P(V) = Pi\text{-}1 + Ki\,(V - Vi - 1) \quad (Vi\text{-}1 \leqq V \leqq Vi) \quad Ki = (Pi - Pi\text{-}1)/(Vi - Vi\text{-}1)$$

where P(V) is a displayed pressure value, V is an input voltage (A/D output), Vi is a voltage input at each calibration point, Pi is calibration pressure at each calibration point (see Fig. 15). Values of each item are recorded in a calibration parameter table (Fig. 16). The number of calibration points to be entered is up to the capacity of the programmable memory 78. In practice, three to five calibration points seem to be sufficient.

[Measuring operation of the present embodiment]

The pressure gauge of the present embodiment is operated in the normal operation as follows.

(1) Four AA batteries 81 as a power source are fitted into the cell case 80 of the pressure gauge 1.

(2) The P/C button 521 is pushed once to turn the power on. The pressure gauge 1 is operated in the normal mode when the power is on.

(3) The U/S button 523 is pushed in the normal mode to set the unit of the displayed measured value to any of Bar, PSI or KPa.

(4) The D/E button 522 is pushed over 4 seconds in the normal mode to change the operation mode to the ID setting mode.

(5) The current ID number is checked on the ID registering screen 53A in the ID setting mode.

(6-1) When the P/C button 521 is pushed in the ID setting mode, return to the normal mode without changing ID number.

(6-2) When the current ID number is incremented, the U/S button 523 is pushed once to display the ID incrementing screen 53B, and the D/E button 522 is pushed to increment the ID number.

(6-3) When the current ID number is decremented, the U/S button 523 is pushed twice to display the ID decrementing screen 53C, and the D/E button 522 is pushed to decrement the ID number.

(7) After incrementing or decrementing the ID number, the U/S button 523 is pushed to switch to the ID registering screen 53A.

(8) The D/E button 522 is pushed once on the ID registering screen 53A to register the ID number displayed at the moment as a new ID number (returning to the normal mode).

(9) The tip of the tube 4 is connected to the tire 21.

(10) The pressure of the tire 21 is measured while monitoring the LCD 53.

(11) The D/E button 522 is pushed once while the measured value (the hold value) is displayed in the normal mode, and released thereafter to transmit the measured value (the hold value).

(12) The above operations (9) to (11) are repeated.

(13) The P/C button 521 is pushed over 2 seconds to turn the power off (changing to the sleep mode).

[Calibration operation during calculation process of the present embodiment]

The pressure gauge of the present embodiment is operated in the calibration operation during calculation process as follows.

(1) After the back cover 55 is detached, the P/C button 521 is pushed while turn the power on with the calibration switch 73 being pushed, so that the operation mode of the pressure gauge 1 is changed to the calibration mode and the LCD 53 displays the current value displaying screen 53D.

(2) The P/C button 521 is pushed to select the calibration value initializing mode (Steps S93, S94) or the D/E button 522 is pushed to select the calibration value setting mode (Steps S95, S951 to S953 and S98) or the U/S button 523 is pushed to select the function customizing mode (Step S9A, S9B) on the current value displaying screen 53D in order to initialize and add the calibration value and to customize the functions.

(3) The P/C button 521 is pushed for over 2 seconds to power off, and then the P/C button 521 is pushed again to power on to implement the normal operation.

[Effects of the present embodiment]

According to the present embodiment as described above, the following effects can be obtained.

(1) Since the measured value of the pressure gauge can be transmitted to the outside, the transcription is not necessary, so that operation efficiency can be improved.

(2) Since the cancel code can be output, inevitable mistake in measuring can be easily dealt with, so that the data processing can be facilitated.

(3) Since the wireless communication is used for the transmission, the operation efficiency can be further improved.

(4) Since the transmission ID of the pressure gauge can be set, plural gauges can be simultaneously used.

(5) Since the display is provided, the measuring operation can be facilitated.

(6) Since the air inlet module is detachable, the air inlet module can be selected in accordance with the working circumstances, so that the measuring operation can be facilitated. Further, the air inlet module can be easily replaced when the air inlet module is worn.

(7) Since the pressure sensor can be replaced together with the sensor PCB, the pressure sensor can be easily replaced when the pressure sensor is damaged.

(8) Since the software calculation routine for conducting the multi-point compensation is provided, accurate calibration can be secured and simplified.

(9) Since the built-in calibration routine for calculation is employed, the calibration in replacing the pressure sensor can be facilitated, so that high accuracy can be constantly secured.

(10) Since the hold function is employed, the measured value can be easily obtained. Further, since the auto-hold function is also employed, the operation efficiency can be improved. Furthermore, even when pressure is applied by a compressor or pressure is reduced by a deflator during measurement, the pressure value can be measured by the auto-hold function.

(11) Since the auto-hold-reset function is employed, the operation efficiency can be improved.

(12) Since the pressure gauge can communicate with the data processor, the transcription is not necessary, so that the operation efficiency can be improved.

(13) Since the customizing menu of the default configuration such as the displayed units and the operation modes is provided, the default configuration can be optionally changed, thereby enabling one firmware to satisfy different configuration requirements.

[Modifications]

Incidentally, the scope of the present invention is not restricted to the above embodiment, but includes modifications and improvements as long as an object of the present invention can be achieved.

For example, although the pressure gauge is used as the measuring instrument in the above embodiment, other measuring instrument such as a tire depth gauge can be used and combination of the measuring instruments may be used.

Although the location of the data processor is fixed in the above embodiment, such arrangement is not limiting but the data processor may be arranged portable. Accordingly, the data can be checked immediately after measuring the tire at the measuring site with the user.

Although the data processing portion of the data processor is the notebook

computer in the above embodiment, a desktop computer or a PDA (personal digital assistant) can be used as the data processing portion.

Although the wireless receiver of the data processor is the PCMCIA standard card in the above embodiment, the wireless receiver can be incorporated in the computer, or other terminals such as RS-232C port can be used for connecting the wireless receiver from the outside.

Although the communication between the wireless transmitter and the wireless receiver is unilateral from the wireless transmitter to the wireless receiver, bilateral communication, in which signal for informing acknowledgement of the data is transmitted from the wireless receiver to the wireless transmitter or a command for transmitting a pressure data is transmitted from the data processor to the pressure gauge can be employed.

Although the tube is connected to the workpiece and the pressure sensor is provided in the pressure gauge in the above embodiment, the pressure sensor can be provided outside the pressure gauge and connected to the pressure gauge through a cable.

Although the sixteen-character monochrome LCD is used as the display, a LED (light-emitting diode) or a colour LCD can be used.

Although the three operation buttons are used as the operating portion in the above embodiment, more than three or less than three buttons can be used. Further, the pressure gauge can be externally operated by a personal computer according to a specific program instead of the button operation.

Although the pressure gauge is in wireless communication with the data processor, the pressure gage can be communicated with the data processor by a cable such as a metallic cable or an optical fibre.

Although the A/D converter, the digital I/O, the MPU, the work memory and the programmable memory are integrated in the microcomputer, each component can be separated.

Although the pair of Bar and PSI or the pair of KPa and PSI is selected and the units included in selected pair of the units are switched to be displayed, only two units of Bar and PSI may be displayed in turn, or three units of Bar/PSI/KPa may be displayed in turn. Alternatively, two units of Bar and PSI may be simultaneously displayed.

Although the unit KPa is used for the data processing inside the pressure gauge,

the other units such as PSI or Bar can be used.

Although the manual-sleep function is arranged to turn the power off by pushing the P/C button 521 for the predetermined time, the pressure gauge 1 may be arranged to turn the power on by pushing the button for a predetermined time in order to avoid turning the power on by mistake during transportation.

Although the measured-value hold function is the stable-value auto-hold function and the peak-value auto-hold function, the measured-value hold function may be a manual-hold function to optionally hold the measured value by manual operation of the operator. The manual-hold function can be realized by using existing measurement circuit technique.

What is claimed is:

1. A pressure gauge, comprising:

a pressure sensor for receiving pressure applied from the outside and outputting a signal corresponding to the pressure;

a processor for processing the signal from the pressure sensor and calculating a measured value;

a transmitter for transmitting the measured value calculated by the processor to the outside; and

an operating portion for operating the processor and the transmitter.

2. The pressure gauge according to claim 1, wherein the processor is adapted to output a cancel code for cancelling preceding transmission data from the transmitter in response to cancel operation of the operating portion.

3. The pressure gauge according to claim 1 or 2, wherein the transmitter is in wireless communication with an external receiver.

4. The pressure gauge according to claim 3, wherein the transmitter has a changeable transmission identification.

5. The pressure gauge according to any one of claims 1 to 4, further comprising a display for displaying the measured value and status of each component.

6. The pressure gauge according to claim 5, wherein the measured value can be converted to be displayed in a predetermined pressure unit in real time.

7. The pressure gauge according to claim 6, wherein plural pressure units can be simultaneously displayed.

8. The pressure gauge according to any one of claims 1 to 7, further comprising a detachable inlet module for accessing the external pressure.

9. The pressure gauge according to any one of claims 1 to 8, wherein the pressure sensor is fixed to a PCB and can be replaced together with the PCB.

10. The pressure gauge according to any one of claims 1 to 9, wherein the processor includes a software calibration routine for conducting multi-point compensation.

11. The pressure gauge according to claim 10, wherein the processor further includes a built-in calibration routine for the calculation.

12. The pressure gauge according to any one of claims 1 to 11, wherein the processor has a hold function to hold the current measured value.

13. The pressure gauge according to claim 12, wherein the hold function is a stable-value auto-hold function to automatically hold the measured value stable for a predetermined time in one measurement cycle.

14. The pressure gauge according to claim 12, wherein the hold function is a peak-value auto-hold function to automatically hold the maximum measured value in one measurement cycle.

15. The pressure gauge according to claim 12, wherein the hold function is a manual-hold function to optionally hold the measured value by an operator performing manual operation.

16. The pressure gauge according to any one of claims 12 to 15, wherein the processor resets the hold value when hold value reset operation is carried out in the operating portion and/or when the next pressure is applied to the pressure gauge.

17. A pressure measuring system, comprising:

a pressure gauge having a pressure sensor for receiving pressure applied from the outside and outputting a signal corresponding to the pressure, a processor for processing

the signal from the pressure sensor and calculating a measured value, a transmitter for transmitting the measured value calculated by the processor to the outside, and an operating portion for operating the processor and the transmitter; and

a data processor having a receiver for receiving the measured value from the transmitter and a processing portion for conducting a predetermined data processing to the received value.

18. The pressure measuring system according to claim 17, wherein the processor outputs a predetermined cancel code in response to cancel operation of the operating portion; and

wherein the receiver cancels the preceding transmission data when the receiver receives the cancel code from the transmitter.

19. The pressure measuring system according to claim 17 or 18, wherein the transmitter is in wireless communication with the receiver.

20. The pressure measuring system according to claim 19, wherein the receiver is adapted to connect a communication channel with plural transmitters and identify each transmitter by a transmission identification.

INVESTOR IN PEOPLE

Application No: GB 0207268.4 **Examiner:** Eleanor Thurston
Claims searched: 1-20 **Date of search:** 18 October 2002

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): G1N (NAAJCR, NACG, NAHJA).

Int Cl (Ed.7): G01L 17/00; G08C17/02.

Other: Online: EPODOC, WPI, PAJ.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2344232 A	(OTTER CONTROLS) see abstract and figure 7.	1, 3, 17, 19 & 20.
X	EP 1116608 A1	(HUANG) see abstract and figure 1.	1, 3, 17, 19 & 20.
X	WO 98/34799 A1	(VEHICLE SENSOR SYSTEMS) see abstract and figure 1.	1, 3, 17, 19 & 20.
X	US 5136285 A	(OKUYAMA)	1-3, 6, 7 & 17-20.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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